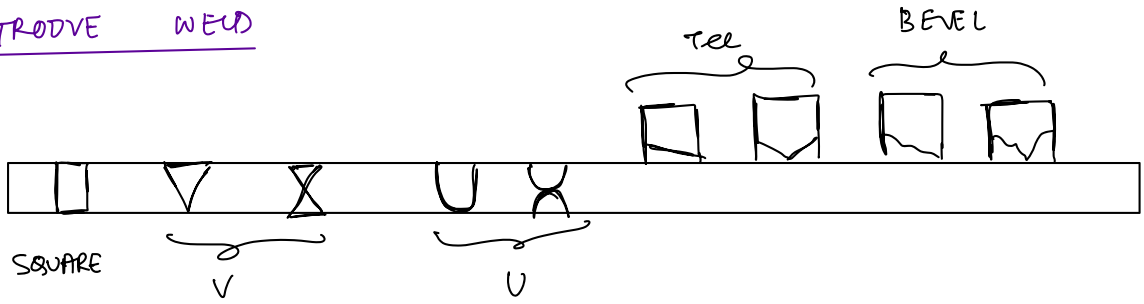
WELDED CONNECTIONS

Reason for using welded joint

1. It provides more efficient use of material
2. The speed of fabrication and erection is appreciable
3. Welding saves weight and hence cuts most. connecting steel plates are reduced or eliminated
4. Welded joints are better in impact loads and vibrations
5. No deductions are there for holes ; the gross section is effective in carrying loads.

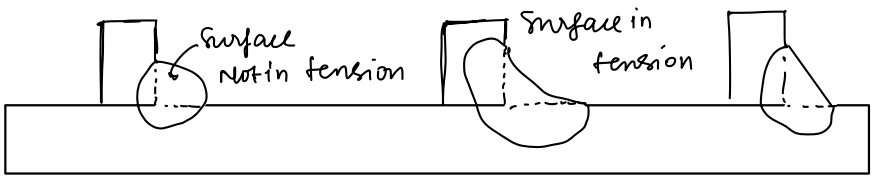
TYPES OF WELD

TYPE OF GROOVE WELD



- Square groove weld is limited to plate thickness of 8mm
- Double V consumes more weld metal but provides complete penetration of weld

TYPES OF FILLET WELD



Convex Convex Flat fillet weld

EASY FABRICATION – Fillet weld > Groove weld

STRESS CONCENTRATION – Fillet weld > Groove weld

COST – Groove weld > Fillet weld.

SYMBOLS USED IN WELDING

Fillet – △

Square – ||

V – V

Bevel – V

U – Y

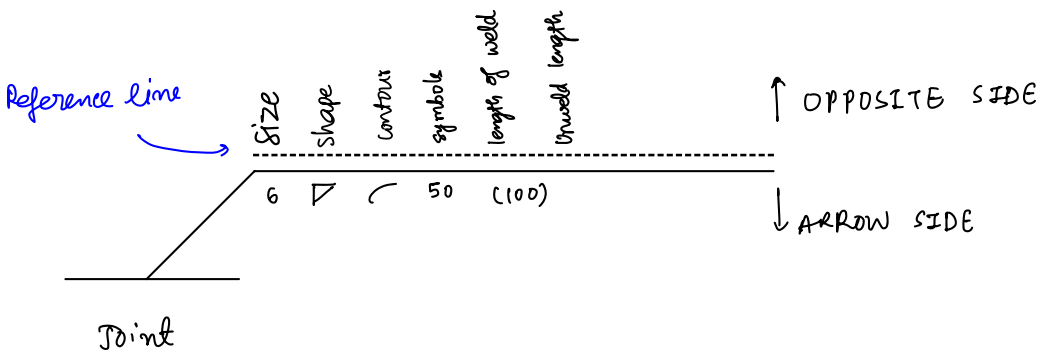
J – P

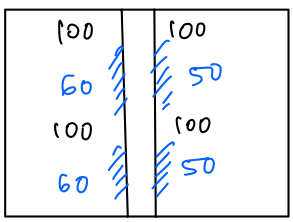
V with broad root face = Y

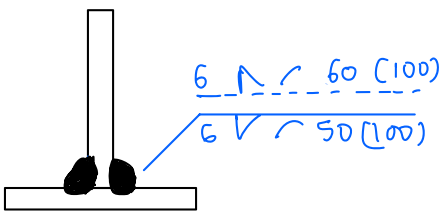
Flat – —

Convex – ⌒

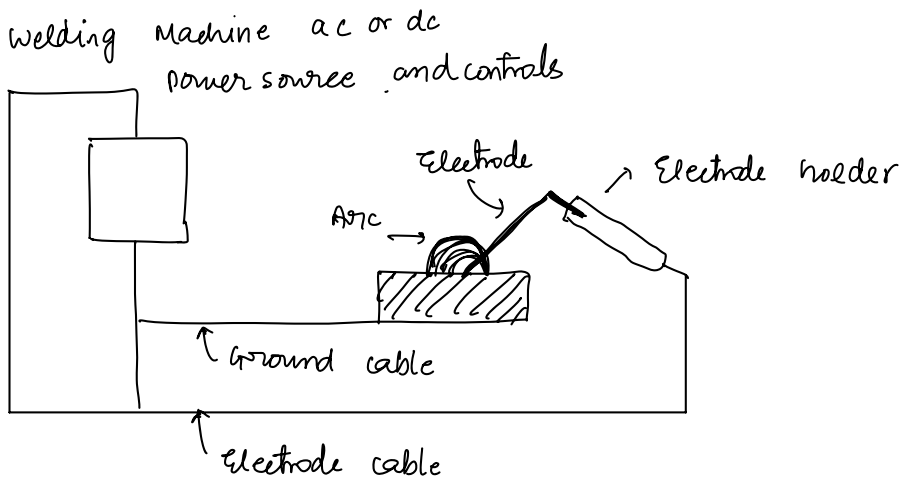
Concave – ⌣







WELDING PROCESS

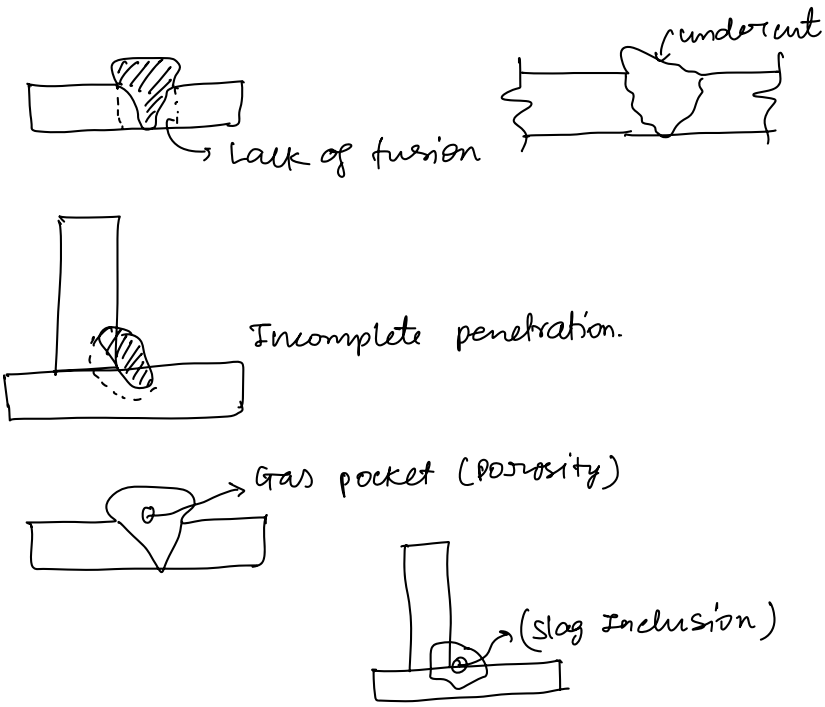


* welding structural steel is $410 N/mm^2$
* Deposit of weld has yield strength around 330 MPa and $f_u$weld > 410MPa

WELD DEFECTS

1) Incomplete fusion
2) Incomplete Penetration
3) Porosity
4) Slag inclusions
5) Undercutting
6) Cracks

} Rapid cooling] CAUSE



ASSUMPTIONS IN ANALYSIS OF WELDED JOINT

1. Welds are homogeneous, isotropic and elastic elements
2. The parts connected by the weld are rigid and and their deformations are therefore neglected.
3. Only stresses due to external loads are considered. Effects of residual stress concentration and shape of welds are neglected.

DESIGN OF GROOVE WELD

Strength of groove weld in tension or compression :-

$$T_{dw} = \frac{f_y \cdot L_w \cdot t_e}{\gamma_{mw}}$$

γ_{mw} → 1.25 (SHOP WELDING)
γ_{mw} → 1.50 (FIELD WELDING)

$f_y \rightarrow \min(f_{y\,weld\,metal},\ f_{y\,base\,metal})$

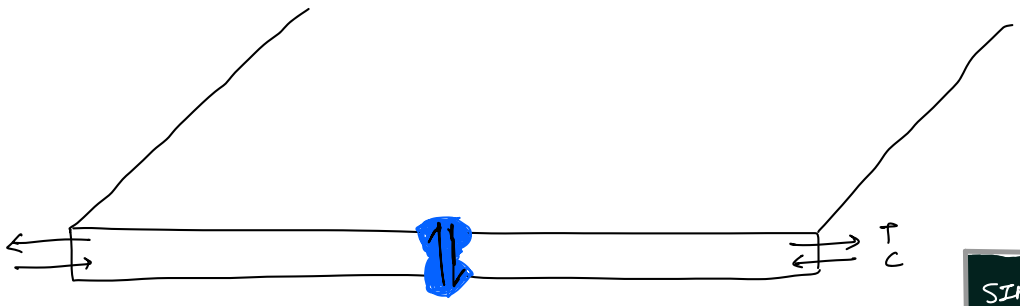
L_w → effective length of weld

t_e → effective throat thickness

Design strength of butt weld in shear :-

$$V_{dw} = \frac{f_y}{\sqrt{3}} \times \frac{L_w \cdot t_e}{\gamma_{mw}}$$

{Effective Area = $L_w t_e$}



SINGLE ⇒ $\frac{5}{8} t = t_e$

DOUBLE = $t = t_e$

t = thickness of thinner members.

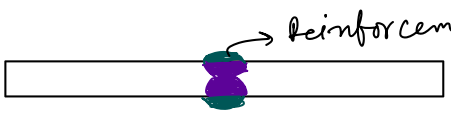
Groove welding ke formulae ⇒ fy aata hai

Note :- Size = throat thickness.

Throat thickness :

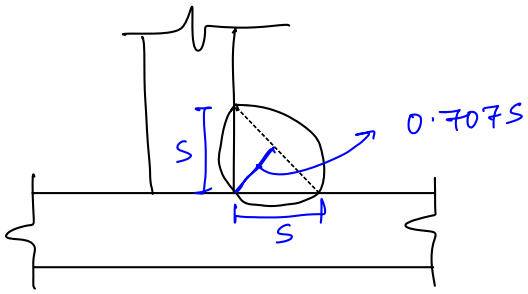
→ single V/V ; $t_e = \frac{5}{8} \times$ thickness of thinner member (INCOMPLETE PENETRATION)

→ Double V/V ; t_e = thickness of thinner member.



{Extra weld metal generally 10-%}

Effective throat thickness (FILLET):



Size of fillet weld.
= leg size of largest isosceles triangle.

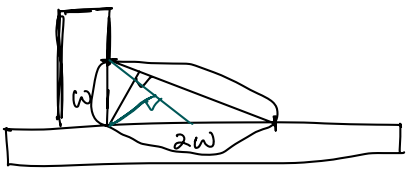
Throat thickness = 0.707S.

Effective Area of weld = Effective length × Effective throat thickness

Angle b/w fusion faces	K
60° – 90°	0.7
91° – 100°	0.65
101° – 106°	0.60
107° – 113°	0.55
114° – 120°	0.50

SIZE OF FILLET WELD

For unequal legs; Size of fillet weld = Smaller leg size



$$\text{size} = \min\left\{ \begin{matrix} w \\ 2w \end{matrix} \right\}$$

Thus $\boxed{\text{size} = w}$

$$\left\{ \begin{matrix} \text{when Area increased by } 100\% \\ \text{Throat thickness } \uparrow\text{ed by } 26\% \end{matrix} \right\}$$

Thickness of weld @ which failure occurs.

MINIMUM THICKNESS OF WELD

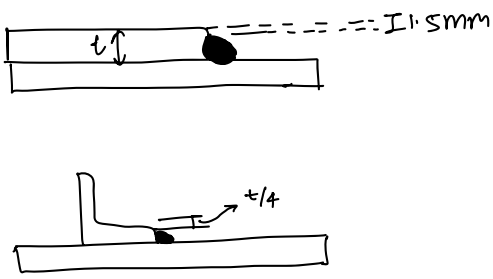
Thickness of thicker member	Size (mm)
over 0 – 10	3
over 10 – 20	5
over 20 – 32	6
over 32 – 50	8 first run, 10

→ Small welds cools and contracts and develope cracks which is not prevented by base metal.

MAXIMUM THICKNESS OF WELD

→ For square edge, $s = t - 1.5\,mm$ {t → smaller plate}

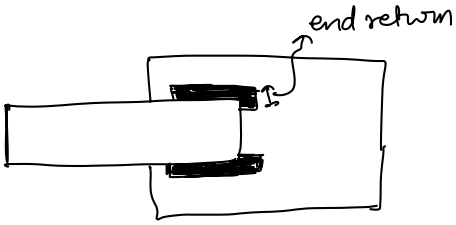
→ For round edge, $s = \frac{3}{4}t$



- For proper inspection; edge of plate should be visible
  ∴ upper size of weld is specified.

EFFECTIVE LENGTH OF WELD

- Effective length = Actual length of weld − 2 × weld size.
- Effective length ≯ 4S



$$\boxed{l_{eff} = L - 2s}$$

* End return of length 2s are provided to relieve the stresses

DESIGN OF FILLET WELD

Design strength of fillet weld

$$f_{wd} = \frac{f_u}{\sqrt{3}} \times \frac{l_w t_e}{\gamma_{mw}} \Big\} \longrightarrow \underline{\underline{LSM}}$$

γ_{mw}: 1.25 (SHOP), 1.5 (FIELD)

$f_u \longrightarrow$ ultimate strength of weld or base metal

$$\text{str of weld} = \sigma_w \times \text{Eff. Area} = 110\ N/mm^2 \times l_w \times t_e \Big\} \longrightarrow \underline{WSM}$$

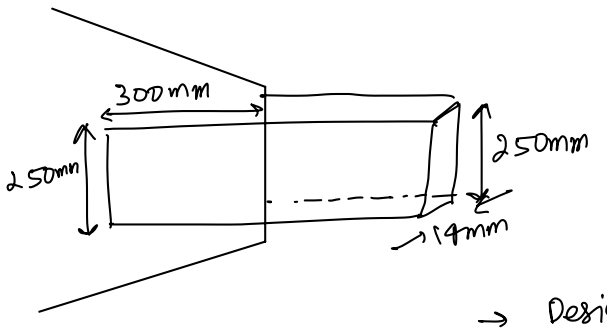
Question

A tie member in a truss girder is 250mm x 14mm in size, it is welded to a 10mm-thick gusset plate by a fillet weld. The overlap of the member is 300mm and the weld size is 6mm. Determine the design strength of a joint, if the welding is done as shown in Figure. What is the increase in strength of the joint, if welding is done all around. Assume shop welding?

Solution

Fe410 ; $f_u = 410\ N/mm^2$, $f_y = 250\ N/mm^2$

size = 6mm, $K = 0.7$, $\gamma_{mw} = 1.25$

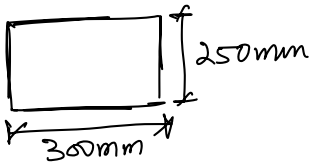


→ effective length = 300 + 250 + 300
= 850mm

→ Design strength = $\frac{410}{\sqrt{3}} \times \frac{850 \times 0.7 \times 6}{1.25 \times 10^3}$

= 676.05 KN.

when welding is done all around,



$\{ l_w = 1100mm \}$

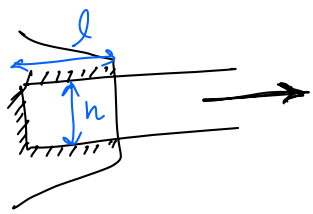
Thus strength = 874.88 kN

$$\text{increase in strength} = \frac{874.88 - 676.05}{676.05} \times 100 = 29.41\%$$

Note

- Each length of longitudinal fillet weld should be greater than $4r$ distance b/w them and provide end returns of 2s.

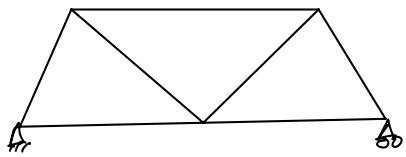
$\{ l > h \}$

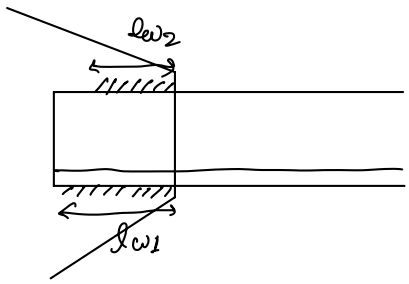


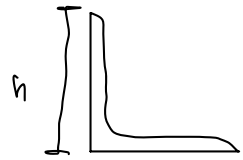
- If $l_j > 150\, t_t$; then design capacity is reduced by β_{lw}

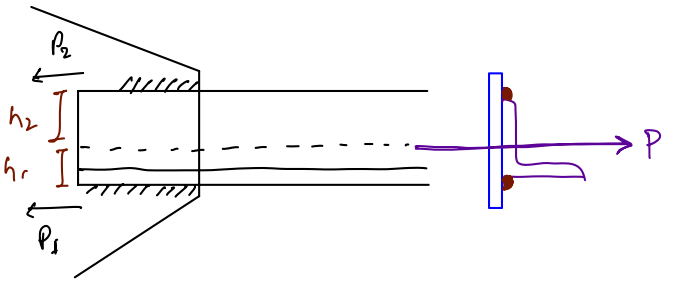
$$\left\{ \beta_{lw} = 1.2 - \frac{0.2\, l_j}{150 t_t} \right\}$$

DESIGN OF FILLET WELD FOR TRUSS MEMBERS









$\boxed{P_1 > P_2}$

The length of weld is more in case of outstanding leg

$$P_1 = \left[\frac{h_2}{(h_1+h_2)}\right] P$$

$$P_2 = \left[\frac{h_2}{h_1+h_2}\right] P$$

$\therefore$ since $h_2 > h_1$

$\therefore P_1 > P_2$

$\Rightarrow l_{w1} > l_{w2}$.

$$\left\{ P_1 = \frac{f_u}{\sqrt{3}} \times \frac{l_{w1}\, t_e}{\gamma_{mw}} \right\}$$

$$\left\{ P_2 = \frac{f_u}{\sqrt{3}} \times \frac{l_{w2}\, t_e}{\gamma_{mw}} \right\}$$

Question

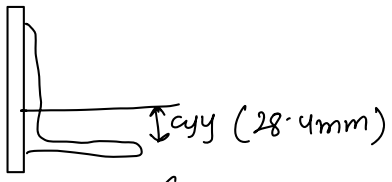
Size of weld = 5mm

effective area of angle section = $1903 mm^2$

Find the length of weld that we provide on both sides.

(ISA 100X100X10)

$\sigma_{at} = 0.6 f_y = 150 \ N/mm^2$



$$\left\{ \begin{array}{l} h_1 = 28.4 mm \\ h_2 = 71.6 mm \end{array} \right\}$$

The maximum permissible force in the area is $\Rightarrow 150 \times 1903 \times 10^{-3}$

$\Rightarrow 285.45 KN$

$$P_1 = \frac{71.6}{100} \times 285.45 = 204.38 KN$$

$$P_2 = 285.45 - 204.38 = 81.07 KN$$

Now for l_{w1},

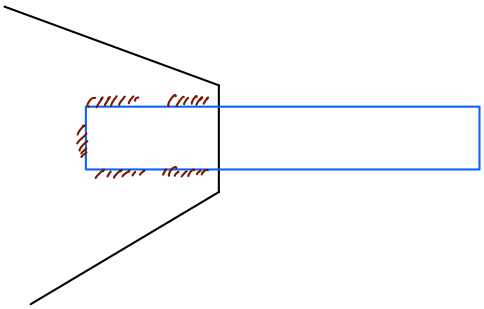
$$204.38 \times 10^3 = \frac{410}{\sqrt{3}} \times \frac{l_{w1} \times 0.7 \times 5}{1.25}$$

$$\{ l_{w1} = 308.36 \text{ mm} \}$$

Similarly,

$$\{ l_{w2} = 122.31 \text{ mm} \}$$

DESIGN OF INTERMITTENT WELDS



→ when strength is required is less than we can provide lesser length in the form of intermittent welds

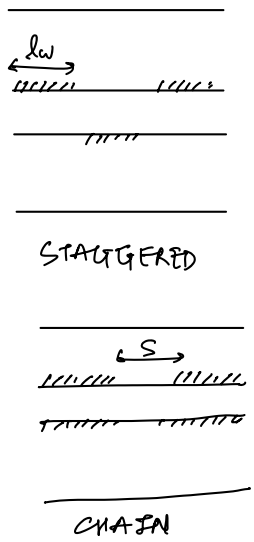
→ Intermittent welds are not economical, until the weld is of smallest size

→ $l_w > 4S$ or 40mm

→ Max spacing.

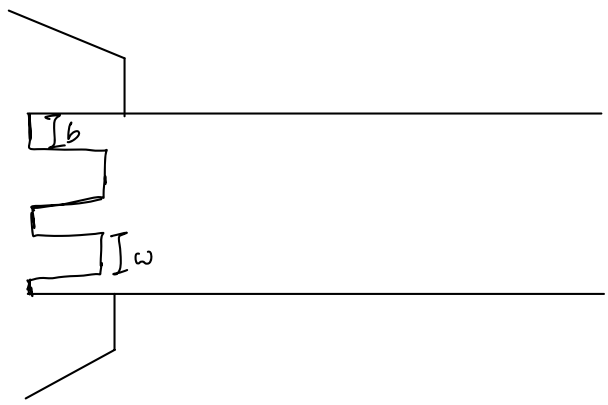
- Tension members → min $\begin{cases} 16t \\ 200mm \end{cases}$

- Compression members → min $\begin{cases} 12t \\ 200mm \end{cases}$



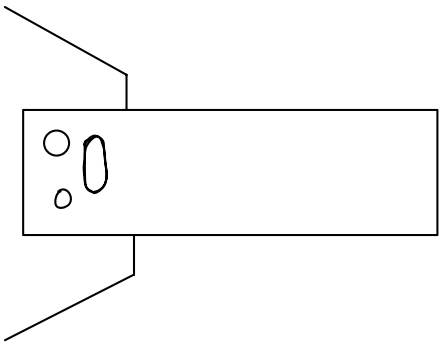
Volume less in case of small fillet size.

PLUG AND SLOT WELD



SLOT WELD

- To ↑s the weld length



→ when the length of weld is not sufficient then in such cases to ↑s length of weld, plugs or slot are provided.

Provision → • width of the slot ≥ 3t

$w \geq 3t$

$b \geq 2t$

• corner radius of slotted hole ≥ 1.5t

≥ 12cm

• clear distance between holes ≥ 2t

≥ 25mm.

COMBINATION OF STRESS

Fillet welds:-

$$\text{Equivalent stress} = f_e = \sqrt{f^2 + 3q^2} \leq \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$$

Butt welds:-

$$\text{Equivalent stress} = f_e = \sqrt{f_b^2 + f_{br}^2 + f_b f_{br} + 3q^2} \leq \frac{f_{y\,metal}}{\gamma_{mw}}$$